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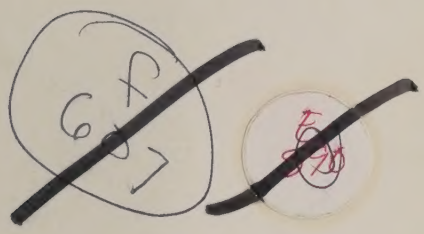
F.E.C.

# instruction manual

## MODEL FCR 250
## FREQUENCY CHANGER



SORENSEN

A UNIT OF RAYTHEON COMPANY

# FCR 250

# INSTRUCTION MANUAL

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SORENSEN/A UNIT OF RAYTHEON CO., Richards Ave., So. Norwalk, Connecticut

14-1730B
9/63

## II. SPECIFICATIONS

| | |
|---|---|
| Input Voltage Range | 105-125 VAC |
| Output Voltage | 115 VAC calibrated ±2% between 105-125V |
| Input Frequency | 50-60 cycles |
| Output Frequency | 320-1000 cps. in two ranges: 320-560, 560-1000. Calibration Acuracy ±2% of maximum setting. |
| Output Voltage Regulation | ±1% |
| Output Frequency Regulation | ±1% in standard model. ±.01% with auxiliary frequency standard. |
| Input Current at Full Load | 15 amperes at 1000 cps. output<br>8 amperes at 400 cps. output |
| Load Range | 0-250 VA. At all frequencies, higher outputs easily obtained at mid frequencies. |
| Output Distortion | 5% nominal |
| PF Range | Unity to zero lagging |
| **Modulation | 2% maximum |

| | |
|---|---|
| Tube Complement (w/o auxiliary Frequencystandard.) | ELC3J/A (2), NL710 (2), 2SM15 (1), 12AU7 (3), AQ5 (4), 6BL7 (1), 0A2 (1), 6X4 (3), 6AH6 (1). |
| Net Weight | Approximately 95 lbs. |
| Ambient Temperature Range | 0-35 °C |

* Thermosen tubes in Sorensen equipment are guaranteed for 5000 hours or one year, whichever expires first.

** This figure assumes no input voltage modulation. If input voltage modulation is present, the output modulation will be directly affected by it.

## III. INSTALLATION AND OPERATION

### A. Terminals, Controls

#### 1. Input Connection

The input power is applied by means of a line cord utilizing a three prong plug. Since the third prong of this plug is connected to the FCR 250 chassis, connection of the line cord to the appropriate receptacle automatically grounds the equipment. If the user does not have three prong outlets available, he should use an adapter. The user should make sure that the extra wire (coded green) coming out from the adapter is solidly grounded to the power line wiring system (preferably soldered). The aforementioned should be carried out for safety reasons and also to minimize radio frequency noise.

#### 2. Stand-By Power

Power is obtained by turning to "On" the toggle switch, SW4, at the left center of the instrument panel.

CAUTION: THE INPUT SWITCH, SW4, DISCONNECTS THE INPUT LINE AFTER THE INPUT FUSE AND FILTERS. FOR SAFETY REASONS THE INPUT LINE SHOULD BE DISCONNECTED EXTERNALLY PRIOR TO WORKING ON THE INSTRUMENT.

#### 3. Rotary Switch

CAUTION: DO NOT ATTEMPT RAPID SWITCHING BETWEEN FREQUENCY RANGES AS THIS WILL LIMIT SWITCH LIFE.

When the rotary switch SW1, at the upper left side of the panel is at positions marked "320-560" or "560-1000," the frequency range is chosen. There are two stand-by positions between the two frequency range positions.

4. Output Terminals

The output is available at two binding posts on the front panel. The input is isolated from the output, and the entire circuitry is capacitor coupled to the chassis ground.

5. Output Voltage ("ON-OFF")

The output voltage may be obtained by momentarily pressing the push button switch, SW2, at the lower right corner of the front panel, approximately 45 seconds after the stand-by power has been turned on. Output voltage is turned off by pressing the same switch.

CAUTION: IF, WHEN ATTEMPTING TO START THE UNIT, THE PUSH BUTTON IS DEPRESSED MORE THAN MOMENTARILY, THE UNIT WILL NOT GO ON.

6. Output Voltage Adjust

The calibrated control on the upper right of the front panel permits voltage adjustment between 105-125 volts. Higher and lower voltages are available with this control, but specifications are not guaranteed.

7. Frequency Adjust

The frequency control mounted on the center of the front panel will adjust the frequency in two ranges, from 320-560 or 560-1000 cps, depending upon the position of the range switch.

B. Fuses

1. Fuse F1 protects the transformer T4 and is mounted at the right center of the front chassis.

2. Fuses F2 & F3, located at the back of the rear chassis, protect the main rectifier circuit from overload.

C. Insertion of the 400 Cycle Auxiliary Frequency Standard

1. This standard will hereafter be designated as the "DRIVER."

2. Normally, the FCR 250 is supplied with a variable frequency oscillator, (320-1000 cps.) This driving source may be switched out of the circuit by switching SW3, located on the rear of the oscillator sub-assembly, to "DRIVER." The latter component is detachable and is optional equipment with space provided for it on the rear chassis.

3. To install the "DRIVER," proceed as follows:

   a. Disconnect the line cord externally and switch the frequency range control to "320-560 cps." Next, SW3 should be switched to "DRIVER."

   b. Remove the rear panel.

   c. Insert driver in 4 mounting holes as indicated on drawing on Page 11.

   d. Attach cable provided internally with unit to both driver and oscillator sub-assembly according to numbers on cable lugs. (1-5 on Driver, 7-11 on oscillator sub-assembly.)

D. Tube Installation

In order to prevent their damage in shipment, the V1 and V2 Rectifier tubes, EL-C3J/A, and the V3 and V4 Inverter tubes, NL-710, have been removed from their sockets and packaged in corrugated cardboard. Please replace them in the sockets before attaching the instrument to the input power line. Each of the two sets of tubes can be placed in either socket marked with the corresponding tube type number. A plate lead must be attached to each tube making sure that the Rectifier tubes and plate caps correspond.

E. Nameplates

Sorensen strongly suggests that the nameplate be retained even if the instrument is to be incorporated into other equipment. This will eliminate later difficulties if service or parts are required.

F. To Place the Unit in Operation

CAUTION: BEFORE OPERATION IS BEGUN, PLEASE REVIEW THE PRECEDING SECTION WITH REGARD TO CONTROLS.

1. Plug the input line cord into a 115V, 60 cycle outlet, as per A-1 above.

2. Turn on the "ON-OFF" toggle switch at the left center of the instrument's panel. This should cause the pilot lamp to light and the filament power is now on.

3. Turn the rotary switch to the frequency range desired.

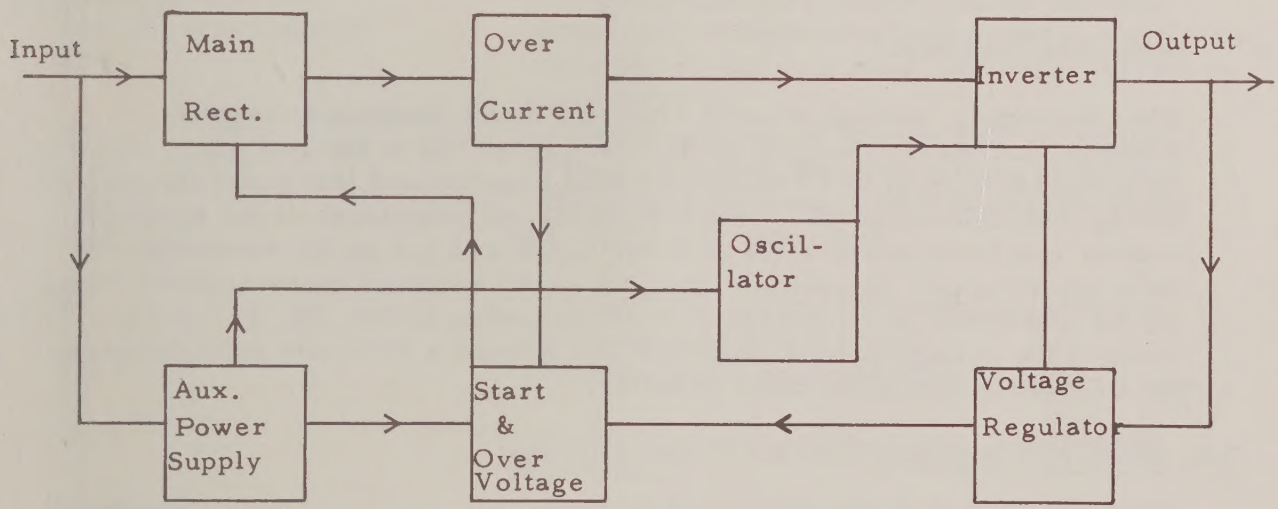
4. Approximately 45 seconds after the previous step has been carried out, momentarily pressing the push button switch will turn on the output. If the unit does not go on, it may be due to the push button switch being pressed for too long a period. In this event, press the switch again for a shorter period of time.

5. To interrupt the output, the push button switch is again momentarily pressed. The instrument may not go off if the push button switch is pressed for too short a period. In this event, press the switch again for a longer period of time.

## IV. PRINCIPLE OF OPERATION

The operation of this instrument can be best understood by referring to the schematic diagram supplied with each instrument.

A. The Block Diagram given below will aid in following the circuitry of the various sections:




B. The frequency changer may be divided into four main sections with auxiliary equipment. Refer to block diagram above.

1. The main sections and their operation are as follows:

   a. Rectifying section consisting of transformer T1, Thyratron tubes V1 and V2, filter choke L1 and filter capacitors C4, C5, and C6. This section rectifies the input to provide DC power for the inverter section.

   b. Inverter section consisting of transformer T3, choke L2, tubes V3 and V4, and capacitors C8 and C9. This section changes the DC voltage to AC voltage.

Operation Sequence:

When the DC voltage is applied, the tube with the positive grid begins to fire. This builds up a voltage across the output transformer T3 dependent upon the components of the RLC circuit seen by the DC supply through the conducting tube. This voltage builds up until the grid of the opposite tube becomes more positive than its critical grid voltage. This tube now fires, cutting off the first tube by means of commutating capacitor C8 and thus completing the cycle across the output transformer. This process is continuous at the frequency of the grid drive supply and gives stable output frequency.

c. Variable Frequency Oscillator (upper right hand corner of schematic), and audio transformer T7.

d. Voltage regulator consisting of controller unit (lower right hand corner of schematic) and saturable core reactor T5.

Operation Sequence:

When the output voltage tries to rise, the diode filament voltage increases, and forces the grid of the first half of V12 to become more negative. This forces the grid of V9 to become less negative and increases the current through the DC coil of T5. This lowers the AC impedance of the saturable reactor and tends to force the inverter output voltage down, restoring it to its original value. In addition, the grid ov V8 becomes more negative changing its impedance in the bridge circuit consisting of R19 20, 21 and V8. This changes the voltage across capacitor C42 in such a direction as to decrease the DC voltage out of the main rectifier.

2. The auxiliary equipment consists of the following:

a. 250 volt power supply with transformer T10, tubes V5 and V15, choke L3, and capacitor C13. This supplies power for the driver section and the overvoltage circuit.

b. Start and stop circuit consisting of one winding of T1, tube V16, and rectifiers S1, S2, Relay K1, and push button switch SW2. This circuit provides DC voltage for the grid circuit of tubes V1 and V2 such that the main rectifier section will supply power to the inverter.

c. Overvoltage sensing circuit consists of relay K1, resistors R45, R46, and R47 together with power supplied from the 250 volt power supply. This circuit compares a DC voltage rectifier from the inverter to a standard DC voltage and opens if the output voltage becomes too high.

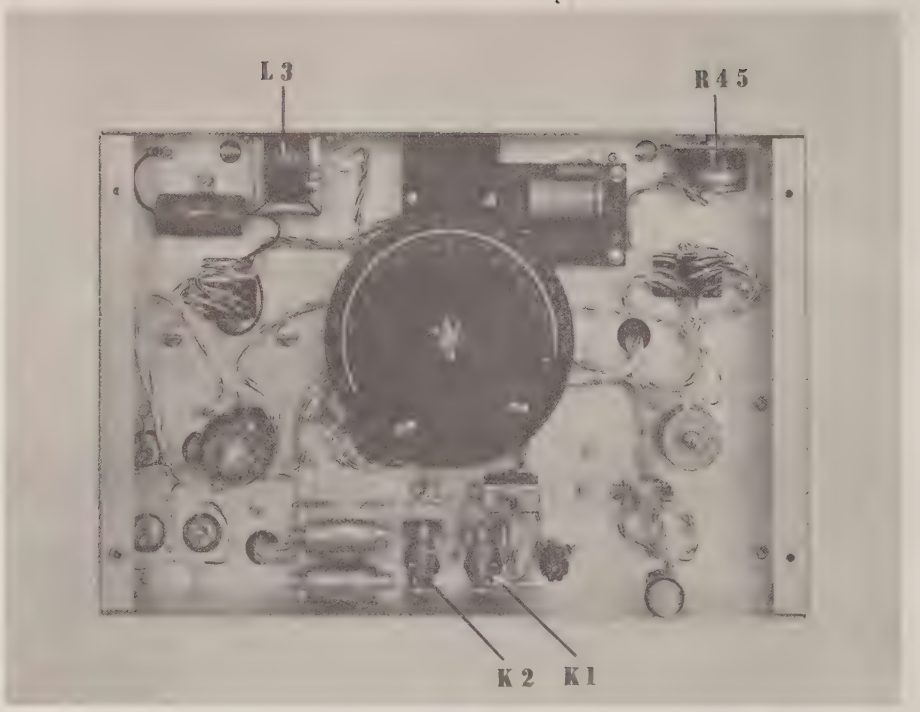
d. Overcurrent sensing circuit consists of relay K2 in conjunction with relay K1. If too high anoutput current is drawn, K2 contacts will open causing negative voltage on the grids of V1 and V2 cutting off the main rectifier. This action is repeated continuously until the instrument is manually shut off (clatering).

C. Listed below are all the components used in this instrument, together with their function. They are presented for your understanding and as a reference source for the functional description of items on the replacement parts list. Reference to the schematic furnished with each instrument will give the position of each component in the circuitry.

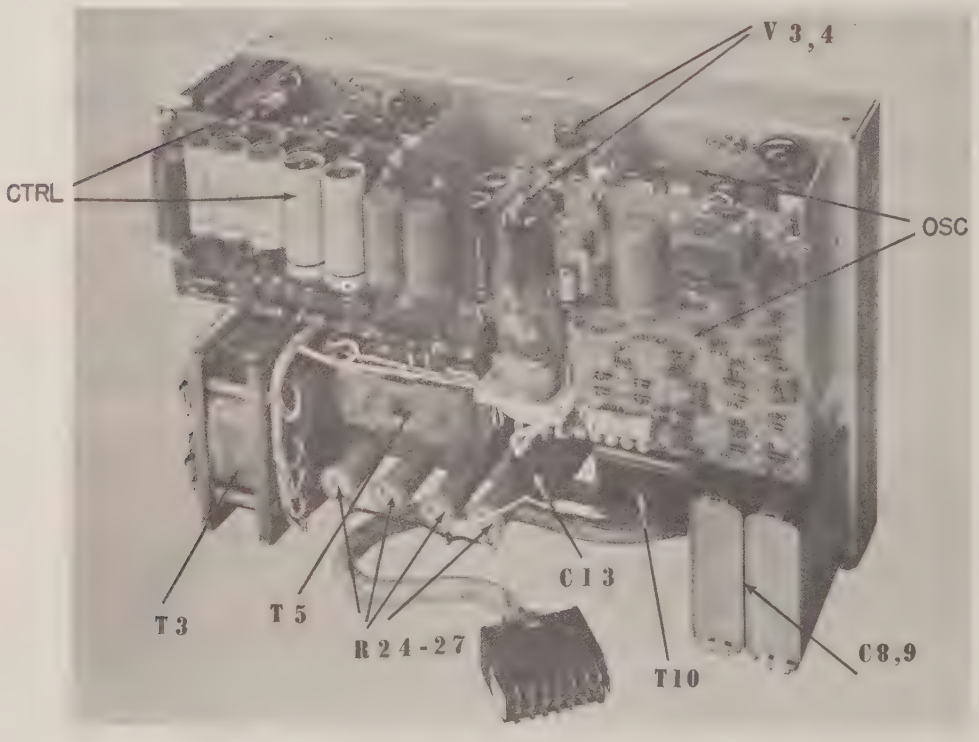
| | |
|---|---|
| C1 | -Wave shaping capacitor in rectifier grid transformer primary |
| C2 | -Phase shift capacitor in rectifying section. |
| C3, 12 | -Filter capacitor, starting circuit |
| C4, 5, 6 | -Filter capacitor, rectifying section. |
| C7, 22, 35 and 36 | -Wave shaping capacitors in Oscillator |
| C8, 9 | -Commutating Choke |
| C10, 11, 52, 53 | -Capacitors to lower grid noise in inverter |
| C13 | -Rectifier filter capacitor. |
| C14 through 19, 23 | -Filter capacitors in voltage control section. |
| C20, 21, 24, 30 and 44 | -Coupling capacitors in Oscillator section. |
| C25, 26, 31 through 34 | -Frequency determining capacitors in Owcillator |
| C38 | -Starting circuit capacitor, provides current to close relay K1. |
| C41 | -Filter Capacitor in voltage control section |
| C42 | -Filter capacitor for grid control rectifier. |
| C50 51 | -Capacitors to lower grid noise in rectifier/ |
| C54 | -B- to ground capacitor. |
| F1 | -2 amp fuse, protects filament transformer T4 from overload (front panel). |
| F2 3 | -20 amp fuses, protects main rectifier |
| G1, 2 | -Radio Frequency noise filter, suppresses RF noise. |
| G3, 4 | -Feed through capacitors, same as G1 and 2. |
| K1 | -Relay, overvoltage circuit, operates if output voltage excessive. |
| K2 | -Relay, overcurrent circuit, operates if output current excessive. |
| L1 | -Filter Choke, rectifying section |
| L2 | -Commutating choke, Inverter section. |
| L3 | -DC Choke, aux. DC supply. |
| M | -Fan motor. |
| PL1 | -Pilot light. |
| PL2 | -Negative feedback stabilizing lamp bulb. |
| R1, 2 | -Series grid resistor, prevents excessive grid current on V1 and 2. |
| R3 | -Start circuit dropping resistor. |

| | |
|---|---|
| R4 | -Phase shift resistor, rectifying section. |
| R5 | -Grid current limiting resistor for V17. |
| R6, 7 | -Grid current limiting resistor for V11. |
| R8 | -Cathode resistor for V11. |
| R9, 10 | -Grid resistors, V3 and V4 |
| R11 | -Bias resistor for V17. |
| R12 | -Series limiting resistor in HV bridge supply circuit to limit peak currents in S3. |
| R13, 14 | - Voltage divider for grid control circuit. |
| R15, 16 | -Voltage divider for grid 1/2 V12. |
| R17 | -Cathode resistor for V12. |
| R18 | -Plate resistor, 1/2 V12. |
| R19, 20, 21 | -Bridge resistors for grid control rectifier. |
| R22 | -Diode, V13, Plate resistor |
| R23 | -Diode, V13, adjust resistor. |
| R24, 25, 26, 27 | -In series with Saturable Core Reactor dissipate power at no load. |
| R28 | -Diode potentiometer voltage regulator. |
| R29, 55, 57 | -Plate resistors, V17. |
| R30, 41 | -Grid bias resistors, V11. |
| R31, 32 | -Frequency determining circuit resistors. |
| R33 | -Plate resistor, V13. |
| R34 | -Negative feedback resistor, Oscillator |
| R35, 36 | -Screen resistors, V14. |
| R37, 38 | -Screen resistors, V10. |
| R39 | -Grid bias resistor, V10. |
| R40, 62, 65 | -Wave shaping resistors. Grid circuit V17. |
| R42 | -Grid circuit loading resistor, V1 and V2. |
| R43 | -Resistor used with C38 in starting circuit. |
| R44 | -Series resistor for V15. |
| R45 | -Limiting potentiometer, determine limit over which overvoltage circuit will operate. |
| R46 | -Series resistor for R45. |
| R47 | -Overvoltage sampling resistor, operates in conjunction with R45 and 46. |
| R48 | -Starting circuit timing resistor. |
| R49 50 | -Control circuit resistors, step up voltage divider for plate of 1/2 V12. |
| R51, 52 | -Plate resistors, V18. |
| R53, 54, 58, 59 | -Wave shaping resistors for V18. |
| R56 | -Main filter capacitor discharging resistor. |
| R60 | -Plate resistor, V10. |
| R63 | -Cathode resistor, V10. |
| R63 | -Cathode Resistor V18. |

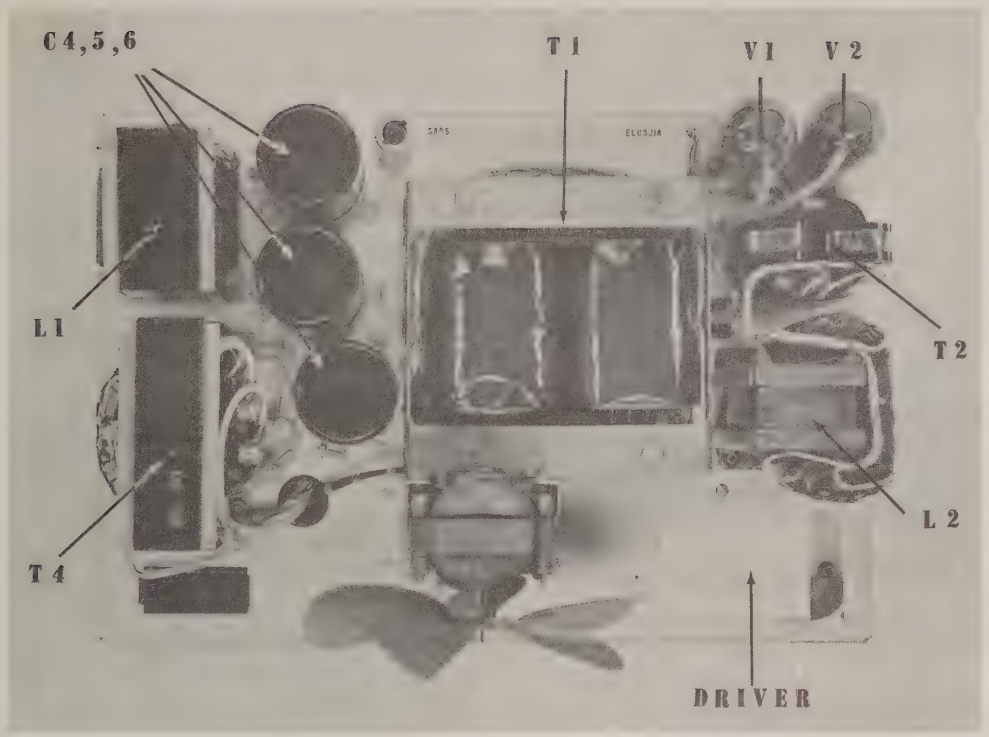
| | |
|---|---|
| R64 | -Cathode Resistor - V17. |
| R66 | -Frequency control potentiometer. |
| R67 | -Frequency range adjustment potentiometer |
| S1, 2 | -Selenium Rectifier, provides negative bias for V1 and V2. |
| S3 | -Selenium rectifier, control circuit, provides negative voltage supply for diode. |
| SW1 | -Rotary switch, selection of cycle range, (front panel). |
| SW2 | -Push button switch, "momentary on-off" output voltage, (front panel) |
| SW3 | -Toggle switch to select Driver or frequency oscillator. |
| SW4 | -Toggle switch !on-off" (front panel) |
| T1 | -Input transformer, rectifying section. |
| T2 | -Grid transformer, rectifying section for main rectifying tubes V1 and V2. |
| T3 | -Output transformer, inverter section. |
| T4 | -Filament transformer |
| T5 | -Saturable core reactor voltage regultor. |
| T7 | -Audio transformer, variable frequency oscillator. |
| T8 | -Plate transformer, grid control circuit. |
| T9 | -Diode Filament transformer, voltage regulator. |
| T10 | -Power transformer, 250 volt power section. |
| V1, 2 | -Thyratron tubes, rectifying section. |
| V3, 4 | -Thyratron tubes, inverter section. |
| V5 | -Rectifier tube, aux. DC power supply. |
| V6, 7 | -Rectifier tube, voltage regulator section. |
| V8 | -Forms bridge circuit with R19 20, and 21, to provide DC voltage control for input rectifier. |
| V9 | -Passing tube for T5, DC coil. |
| V10, 14 | -Part of Wein bridge circuit, oscillator. |
| V11 | -Power amplifier tube, variable frequency oscillator output. |
| V12 | -DC amplifier tube in control circuit. |
| V13 | -Temperature limited diode, output voltage reference tube. |
| V15 | -Provides reference voltage for overvoltage circuit. |
| V16 | -Rectifying section, decreases bias to permit V1, and V2 firing. |
| V17 | -Wave shaping tube, oscillator circuit. |
| V18 | -Frequency divider, oscillator circuit. |



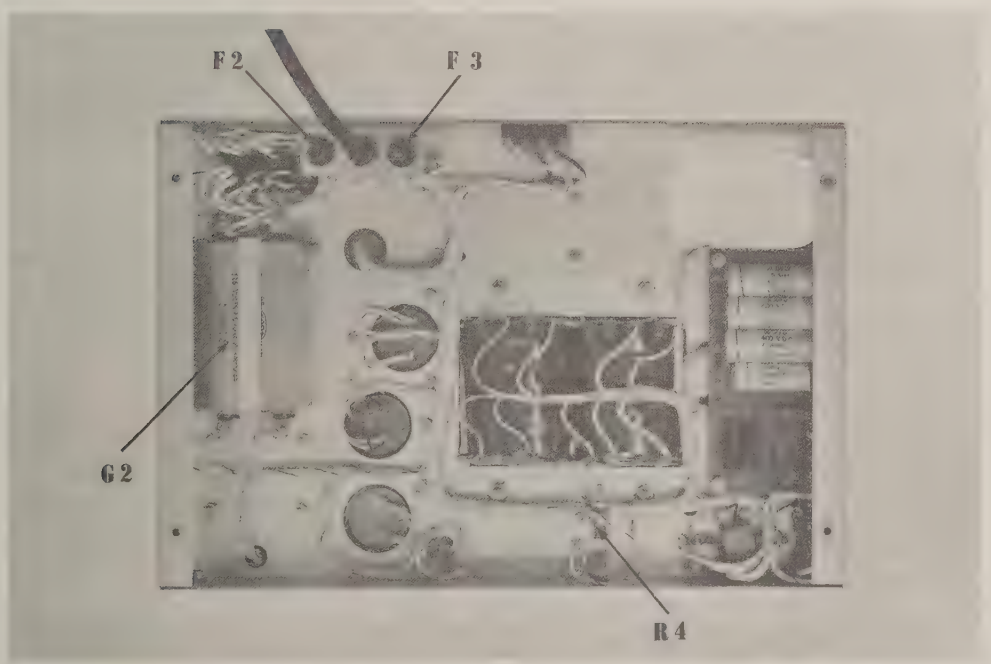

Front Chassis - Front View (Panel Removed)




Front Chassis - Rear View




Rear Chassis - Front View




Rear Chassis - Rear View

## V. MAINTENANCE AND REPAIR

### A. Maintenance

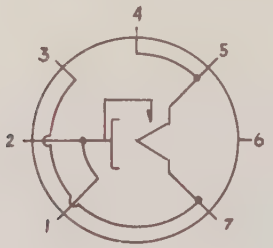
1. During normal life the unit requires no maintenance or servicing other than the care usually afforded this type of equipment. Tubes should be replaced at the end of their specified life in accordance with the policies established for the particular applications.

2. 2SM15 Tube Data

In almost all cases it will be found that the 2SM15 tube is good if the filament is intact; however, for those customers who wish to set up special tests, the following data is included:

Filament -- 1.8 volts DC/AC
310 - 335 ma

Plate -- 500 volts DC
.410 - .550 ma DC




Note that the 2SM15 tube is designed so that the filament (cathode) shorts to the plate when the filament opens. This feature is used to lower the output voltage of the Frequency Changer in the event of 2SM15 tube failure.

3. Spare Parts

All components in the Frequency Changer are of a good commercial grace and can be expected to give a reasonably long period of trouble-free service. As the age of the instrument increases, however, some components are likely to deteriorate; we therefore suggest that the customer keep on hand the spare parts as indicated by an asterisk on the Parts List supplied with the unit. In the event it becomes necessary to replace any part, we strongly suggest that the replacement parts be of the same value as the original. Substitute parts should not be used unless we advise that the substitute part will not impair the performance of the instrument.

B. Repair & Trouble Shooting

In the event of malfunctioning of the unit due to deterioration or failure of any of its component parts, a systematic checking procedure will provide the quickest and surest method of locating the difficulty. The following section gives systematic checking procedures which should be followed in locating sources of trouble.

CAUTION: DANGEROUS VOLTAGES EXIST IN THIS INSTRUMENT. PLEASE OBSERVE APPROPRIATE PRECAUTIONS.

The first step in trouble shooting should be to replace tubes. In most cases this is enough to cure the trouble. However, if the disassembly of the instrument is required, it should be done as follows:

1. Remove the top cover via the four (4) machine screws.
2. Loosen the two (2) allen-head set screws and remove the knob of the Frequency Range Adjust.
3. Remove the front panel via the four (4) machine screws.
4. Remove the rear cover via the four (4) machine screws.
5. Remove the bottom cover via the four (4) machine screws.
6. Disconnect the inter-connecting cable from the rear chassis via the Jones Locking Plug.
7. Loosen the eight (8) locking machine screws, four (4) from each end bell, and loosen the end bells from the front chassis so that the dowell pins clear the chassis. The front chassis may now be lifted from the end bells via the slots provided in the chassis.
8. The rear chassis may be separated from the end bells in a similar manner if required. Caution should be observed to not damage the fan blade upon removal of the chassis.
9. Re-assembly to the instrument should be made following the same procedure.

(1) If the instrument fails to start and the pilot light does not light, check F1. If it still does not light, check F2 and F3. In the event this does not disclose the cause of difficulty, check switch SW4 and plug terminals A7 and A10.

(2) If the instrument starts but actuates Relay K1 due to overvoltage, the control circuit is not functioning. In this case the instrument may be started by placing sufficient load on the output to hold the output down. Use 300-400 WATTS OF RESISTANCE LOAD. DO NOT USE LAMP BULBS FOR LOADING PURPOSES. After the instrument is started:

a. Determine whether the diode V13 is lit. If this tube is not lit, then check the voltage at terminals 3 and 4 of T9. This voltage should be approximately 2.5 volts. If this voltage is present, then check for voltage at the tube filament pins.

b. Measure the voltage across the AC coil (terminals 4 to 4) of T5. If this voltage reads zero, the circuit is open. In this case turn the unit off and check continuity of the circuit, consisting of R24, R25, R26, R27, and T5.

c. The DC coil of T5 (terminals 1 & 2) may be opened or shorted. Check these possibilities by reading the resistance across these termianls. The resistance should be 2000 ohms.

d. Check the rectifier circuits, employing V6 and S3. These circuits should provide voltages as shown on the schematics. If it does not, check the voltages across 5 to 6, and 11 to 6 on transformer T3. Each voltage should be 300 volts AC. If this voltage is present, then check continuity of V6 and S3.

e. Check the V9 and V12 circuits for continuity and resistance values.

(3) If the unit starts but the output is low,

a. Check the diode to see if the plate and filament are shorted. (Refer to 2SM15 tube data, Paragraph A2.)

b. Check the voltage across the DC coil, terminals 1 and 2 of T5. If this voltage cannot be controlled by the potentiometer R28, the control circuit is not operating properly. Then check DC voltage across C18. If this voltage is zero, V7 may be defective (or the V7 circuit may be open).

c. Check the remainder of the control circuit (V9, V12) for continuity and resistance values.

(4) If the unit fails to start:

a. See that relay K1 closes when the push button is operated. (The two relays are mounted behind the front panel and K1 is on the right facing the front of the unit.)

b. Check to see if K2 is closed initially.

c. Check for oscillator voltage across 4 and 6 of T7. Also check the possibility of a defective input transformer T1.

(5) If the unit goes off immediately after starting:

a. Check both K1 and K2 to determine if either becomes actuated.
If K1 becomes actuated, then control circuit is malfunctioning.
If K2 becomes actuated (at no load) then check according to 4c above.

b. The unit will go off when the output is shorted or when the load on the unit is substantially higher than rated. The unit may go off when the load consists of elements which present a low impedance before the warm-up (i.e., lamps).

d. The unit will go off if commutating capacitor C8 and/or C9 is defective.

d. Unit will go off if wound components L2, T3, T5 are defective.

Note 1 Relay K1:

If the instrument malfunctions at any time, including the initial starting, the relay, K1, will continue "clicking off" until the fault is corrected.

Note 2: The control circuit and the oscillator circuit are designed mechanically as unit sub-assemblies. Therefore, each may be electrically and mechanically removed by rotating counter-clockwise 1/4 turn the DZUS fasteners, associated with each sub-assembly. To replace the sub-assembly, place the connectors loosely together and starting with the fastener at the top left, go clockwise until all fasteners are locked.

IN THE EVENT OF **SERIOUS** DIFFICULTY OR DAMAGE TO THIS INSTRUMENT, WE STRONGLY SUGGEST THAT CONSIDERATION BE GIVEN TO RETURNING IT TO THE FACTORY FOR REPAIR.

# GENERAL INFORMATION

## WARRANTY

SORENSEN/A Unit of Raytheon Company, warrants each instrument it manufactures to be free from defects in material and workmanship. The company's obligation under this warranty is limited to servicing the instrument and replacing defective parts*, when the instrument is returned to the factory with transportation charges prepaid. This warranty is effective for one year after delivery of the instrument to the original purchaser. Defects caused by improper operating conditions, misuse, negligence, or the alteration or removal of the nameplate, will void the warranty. SORENSEN shall in no circumstance be liable for any direct or consequential loss or damage of any nature resulting from the malfunction of the instrument. This warranty is effective in lieu of any or all other obligations or liabilities on the part of SORENSEN/A Unit of Raytheon Company, its agents, or representatives.

## SERVICE INFORMATION

Questions concerned with the operation, repair, or servicing of this instrument should be directed to the nearest Sorensen representative (a list is included with this manual) or to the Service Department., Sorensen/A Unit of Raytheon Company, Richards Avenue, South Norwalk, Connecticut. *Include the model number and serial number,* in any correspondence concerning this instrument.

## SHIPPING DAMAGE

It is possible for equipment to be damaged in shipment. Therefore, it is imperative that the instrument be tested and inspected as soon as it is received. If the instrument shows signs of damage, follow the instructions on the DAMAGE and/or Loss in Shipment form enclosed with the unit and notify the carrier immediately. The carrier's claim agent will then prepare a report of damage and, after you have forwarded this to the Sorensen Service Department, you will be advised as to the action necessary to have the instrument repaired or replaced.

## RETURNS TO THE FACTORY

Should it be necessary to return an instrument to the factory for repair, please contact the Sorensen Service Department for authorization to make shipment.

**DO NOT RETURN THE UNIT FOR REPAIR WITHOUT THIS AUTHORIZATION.**

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* The warranty excludes special purpose tubes, which carry their own manufacturer's warrantees, and fuses.

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